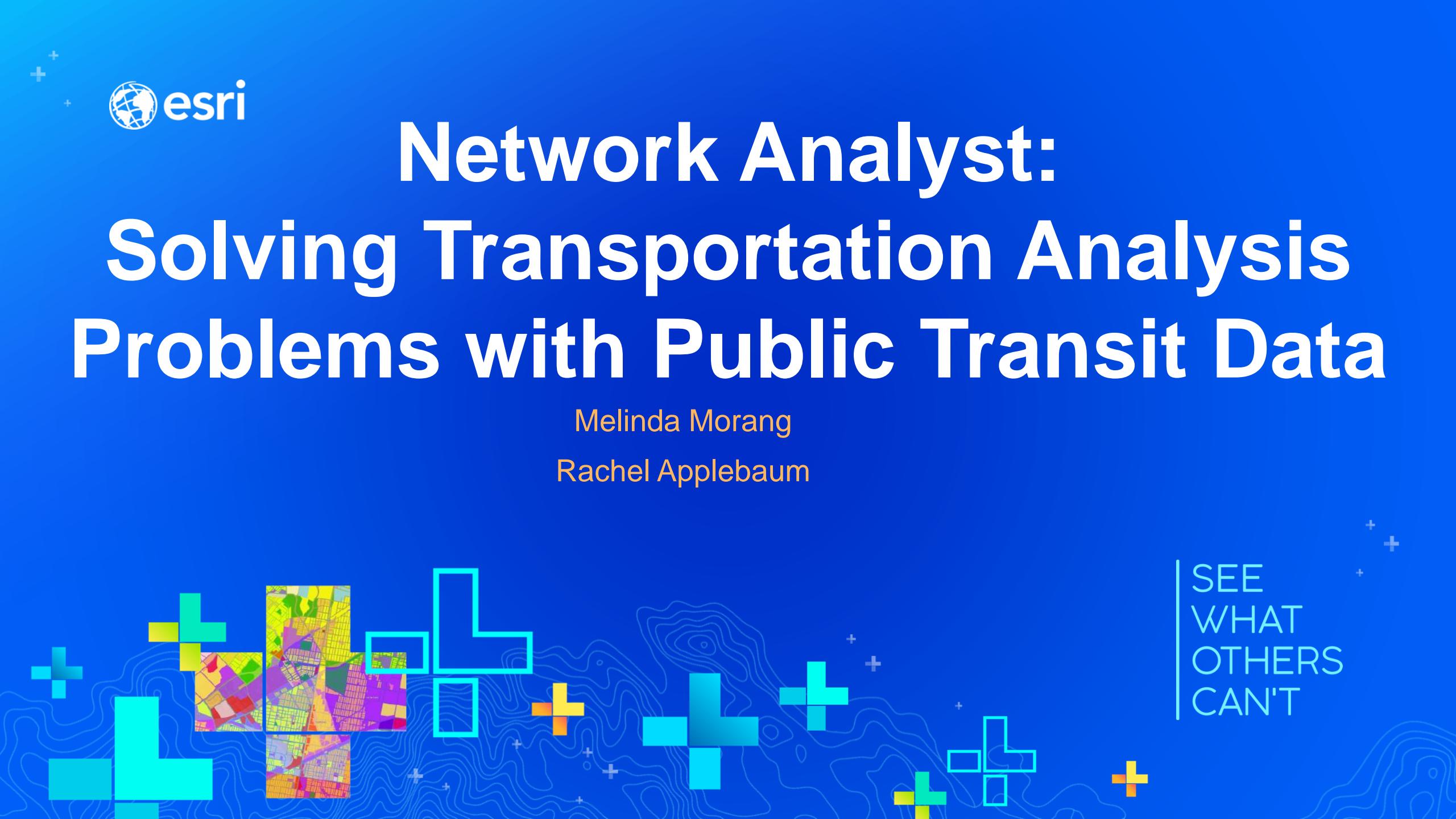




Network Analyst: Solving Transportation Analysis Problems with Public Transit Data

Melinda Morang

Rachel Applebaum

A decorative background featuring a map with contour lines and several colorful, abstract icons resembling stylized plus signs or data blocks in shades of blue, green, and yellow, scattered across the surface.

SEE
WHAT
OTHERS
CAN'T

Agenda

Outline

- **Background information**
- **Creating a network dataset with public transit**
- **Example analysis: Analyzing access to jobs by public transit**
- **Other cool things**

Topics

- **GTFS data**
- **Network Analyst**
- **Public transit data model**
- **Network datasets**
- **Service areas**

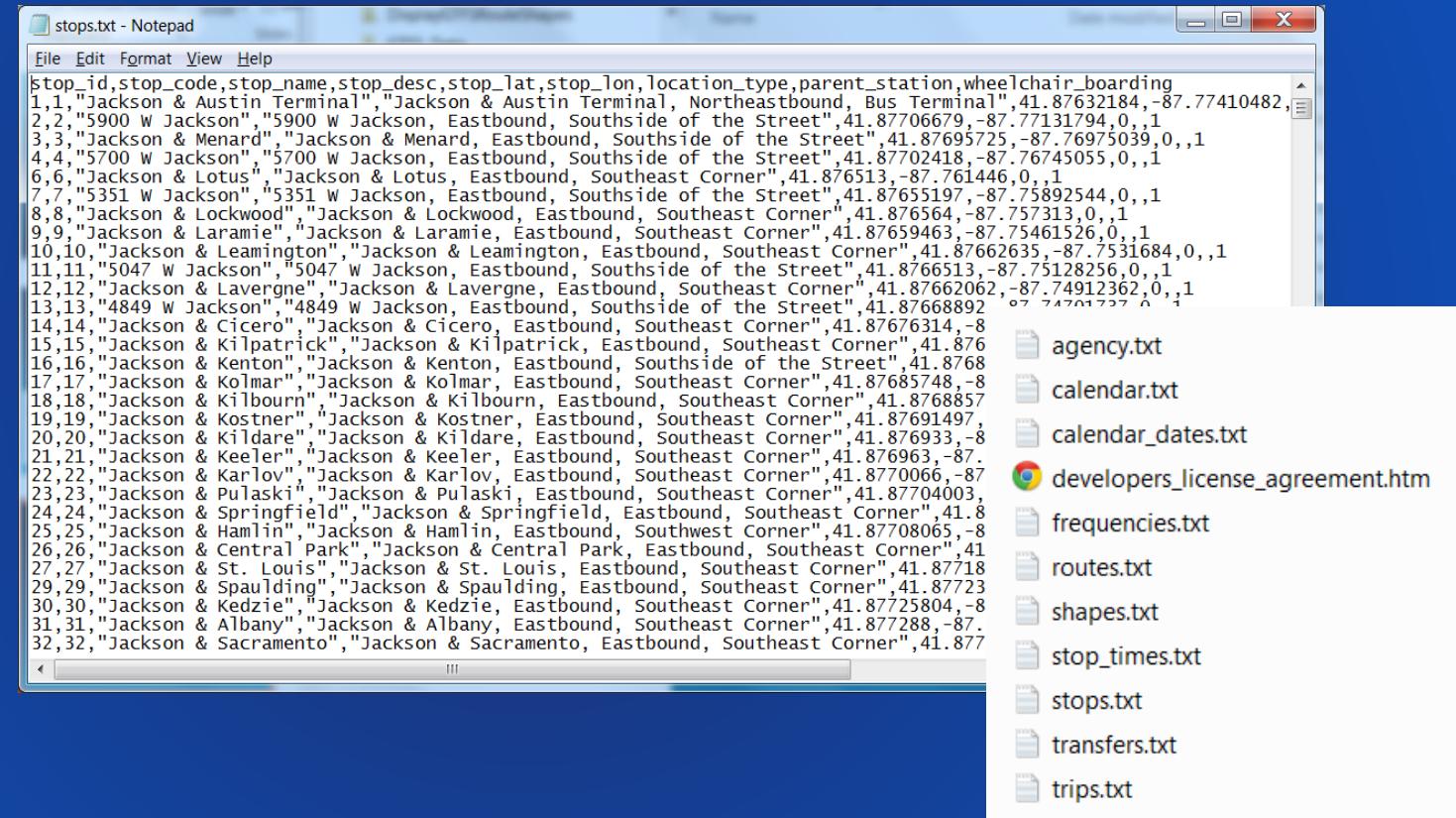


Background Information

GTFS public transit data

Stops, routes, & schedules

- Standardized
- Simple
- Widespread



The screenshot shows a Windows Notepad window titled "stops.txt - Notepad" displaying a list of bus stops. The data is structured as a CSV file with columns: stop_id, stop_code, stop_name, stop_desc, stop_lat, stop_lon, location_type, parent_station, wheelchair_boarding. The sidebar lists other GTFS files: agency.txt, calendar.txt, calendar_dates.txt, developers_license_agreement.htm, frequencies.txt, routes.txt, shapes.txt, stop_times.txt, stops.txt, transfers.txt, and trips.txt.

stop_id	stop_code	stop_name	stop_desc	stop_lat	stop_lon	location_type	parent_station	wheelchair_boarding
1,1	"Jackson & Austin Terminal"	"Jackson & Austin Terminal	"Jackson & Austin Terminal, Northeastbound, Bus Terminal"	41.87632184	-87.77410482			
2,2	"5900 W Jackson"	"5900 W Jackson, Eastbound, Southside of the Street"	"41.87706679,-87.77131794,0,,1					
3,3	"Jackson & Menard"	"Jackson & Menard, Eastbound, Southside of the Street"	"41.87695725,-87.76975039,0,,1					
4,4	"5700 W Jackson"	"5700 W Jackson, Eastbound, Southside of the Street"	"41.87702418,-87.76745055,0,,1					
6,6	"Jackson & Lotus"	"Jackson & Lotus, Eastbound, Southeast Corner"	"41.876513,-87.761446,0,,1					
7,7	"5351 W Jackson"	"5351 W Jackson, Eastbound, Southside of the Street"	"41.87655197,-87.75892544,0,,1					
8,8	"Jackson & Lockwood"	"Jackson & Lockwood, Eastbound, Southeast Corner"	"41.876564,-87.757313,0,,1					
9,9	"Jackson & Laramie"	"Jackson & Laramie, Eastbound, Southeast Corner"	"41.87659463,-87.75461526,0,,1					
10,10	"Jackson & Leamington"	"Jackson & Leamington, Eastbound, Southeast Corner"	"41.87662635,-87.7531684,0,,1					
11,11	"5047 W Jackson"	"5047 W Jackson, Eastbound, Southside of the Street"	"41.8766513,-87.75128256,0,,1					
12,12	"Jackson & Lavergne"	"Jackson & Lavergne, Eastbound, Southeast Corner"	"41.87662062,-87.74912362,0,,1					
13,13	"4849 W Jackson"	"4849 W Jackson, Eastbound, Southside of the Street"	"41.87668892,-87.74701777,0,,1					
14,14	"Jackson & Cicero"	"Jackson & Cicero, Eastbound, Southeast Corner"	"41.87676314,-8					
15,15	"Jackson & Kilpatrick"	"Jackson & Kilpatrick, Eastbound, Southeast Corner"	"41.876					
16,16	"Jackson & Kenton"	"Jackson & Kenton, Eastbound, Southside of the Street"	"41.8768					
17,17	"Jackson & Kolmar"	"Jackson & Kolmar, Eastbound, Southeast Corner"	"41.87685748,-8					
18,18	"Jackson & Kilbourn"	"Jackson & Kilbourn, Eastbound, Southeast Corner"	"41.8768857					
19,19	"Jackson & Kostner"	"Jackson & Kostner, Eastbound, Southeast Corner"	"41.87691497,					
20,20	"Jackson & Kildare"	"Jackson & Kildare, Eastbound, Southeast Corner"	"41.876933,-8					
21,21	"Jackson & Keeler"	"Jackson & Keeler, Eastbound, Southeast Corner"	"41.876963,-87					
22,22	"Jackson & Karlov"	"Jackson & Karlov, Eastbound, Southeast Corner"	"41.8770066,-87					
23,23	"Jackson & Pulaski"	"Jackson & Pulaski, Eastbound, Southeast Corner"	"41.87704003,					
24,24	"Jackson & Springfield"	"Jackson & Springfield, Eastbound, Southeast Corner"	"41.87708065,-8					
25,25	"Jackson & Hamlin"	"Jackson & Hamlin, Eastbound, Southwest Corner"	"41.87708065,-8					
26,26	"Jackson & Central Park"	"Jackson & Central Park, Eastbound, Southeast Corner"	"41					
27,27	"Jackson & St. Louis"	"Jackson & St. Louis, Eastbound, Southeast Corner"	"41.87718					
29,29	"Jackson & Spaulding"	"Jackson & Spaulding, Eastbound, Southeast Corner"	"41.87723					
30,30	"Jackson & Kedzie"	"Jackson & Kedzie, Eastbound, Southeast Corner"	"41.87725804,-8					
31,31	"Jackson & Albany"	"Jackson & Albany, Eastbound, Southeast Corner"	"41.877288,-87					
32,32	"Jackson & Sacramento"	"Jackson & Sacramento, Eastbound, Southeast Corner"	"41.877					

Download directly from the transit agency or from transitfeeds.com

ArcGIS Network Analyst Extension for transportation analysis

Coverage



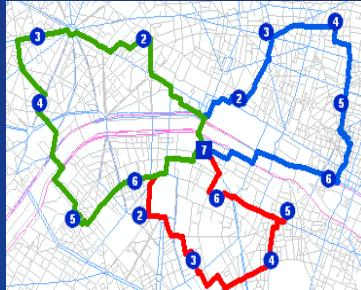
Service Area

Optimization



Location-Allocation

Vehicle Routing Problem



Point-to-point routing

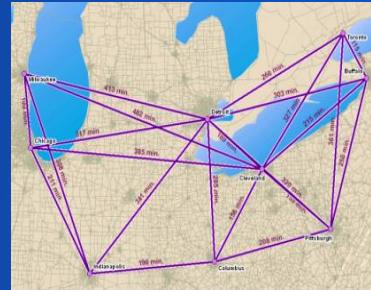


Route



Closest Facility

Origin-Destination Cost Matrix



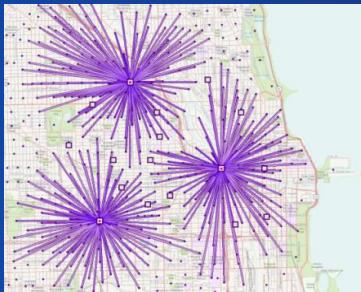
ArcGIS Network Analyst Extension for transportation analysis

Coverage



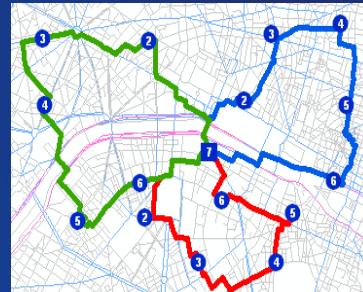
Service Area

Optimization



Location-Allocation

Vehicle Routing Problem



Vehicle Routing Problem

Point-to-point routing

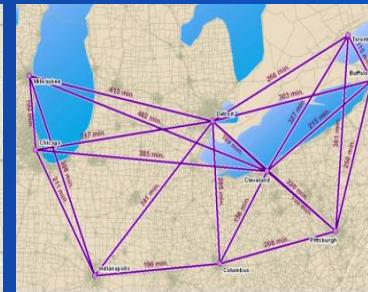


Route



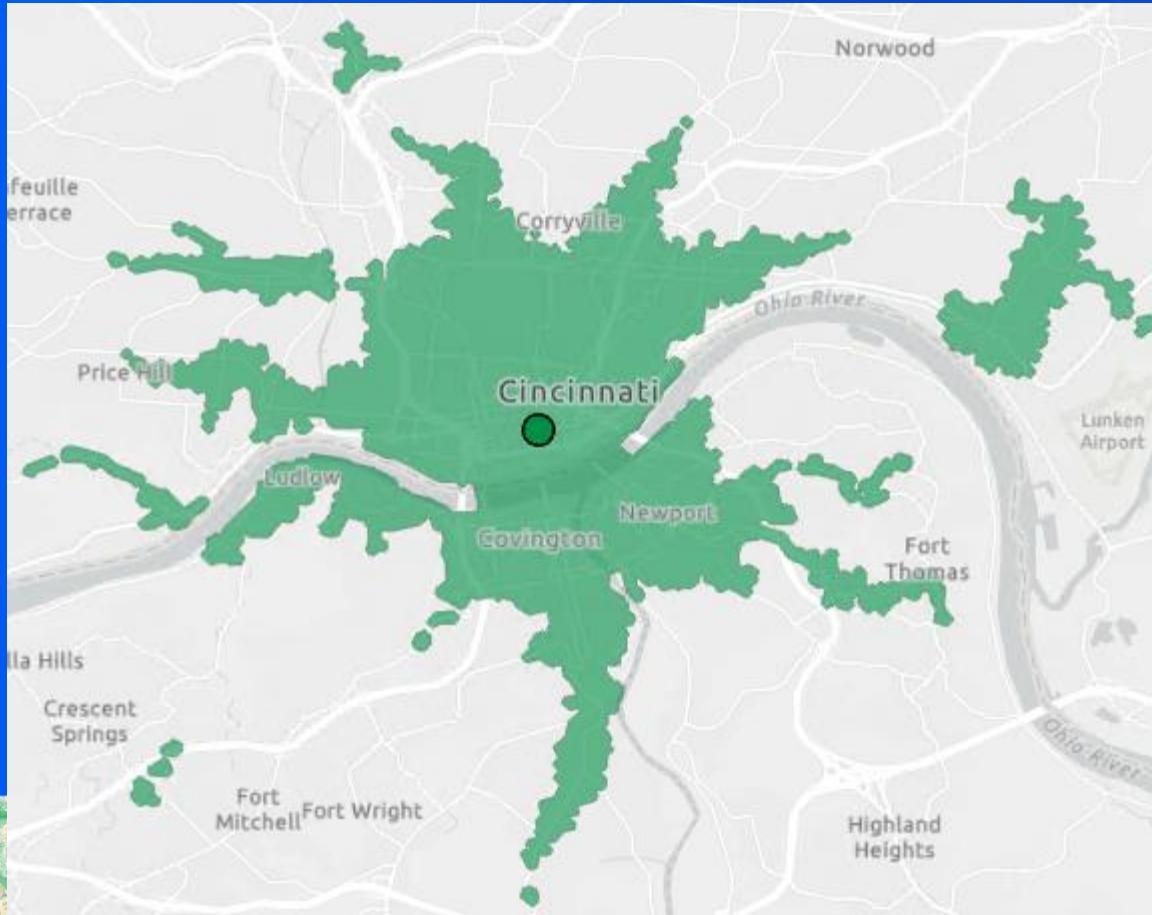
Closest Facility

Origin-Destination Cost Matrix



Network Dataset





+

Demo: Where can I reach by public transit?

Creating a network dataset with public transit



There's a tutorial!!

<http://esriurl.com/TransitTutorial>

Creating a network dataset with public transit data

Procedure

Inputs:

- Public transit data (GTFS or other format)
- Street centerlines

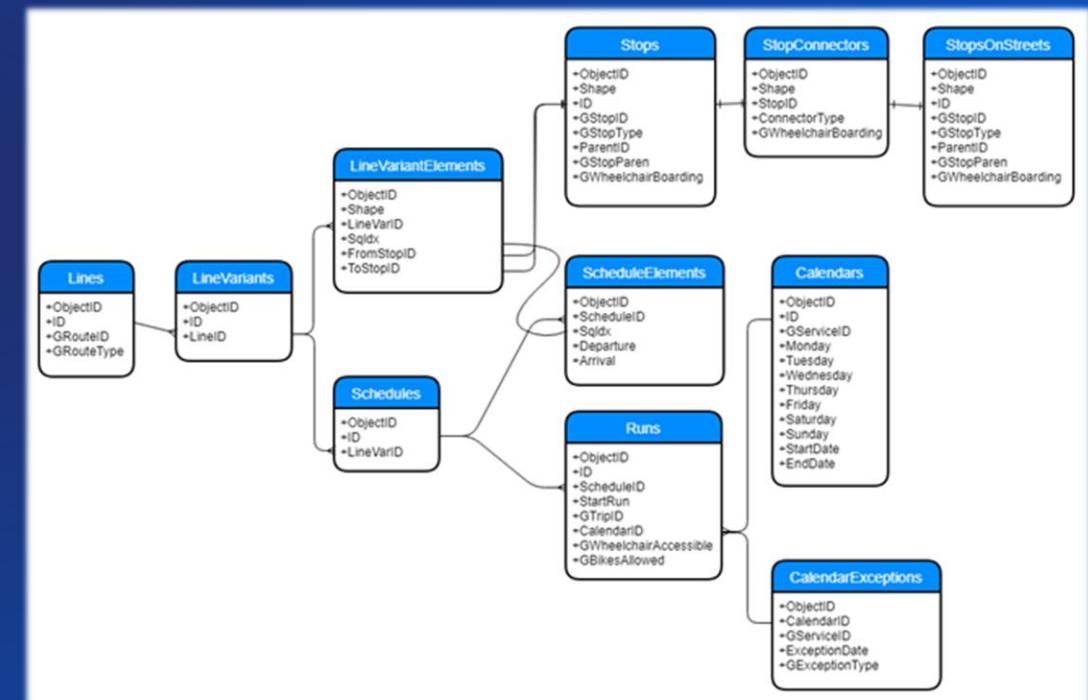
Procedure:

1. Convert transit data into the Network Analyst public transit data model
 - a. GTFS To Network Dataset Transit Sources
 - b. Connect Network Dataset Transit Sources To Streets
2. Create network dataset using a template
3. Adjust network dataset properties
4. “Build” network dataset

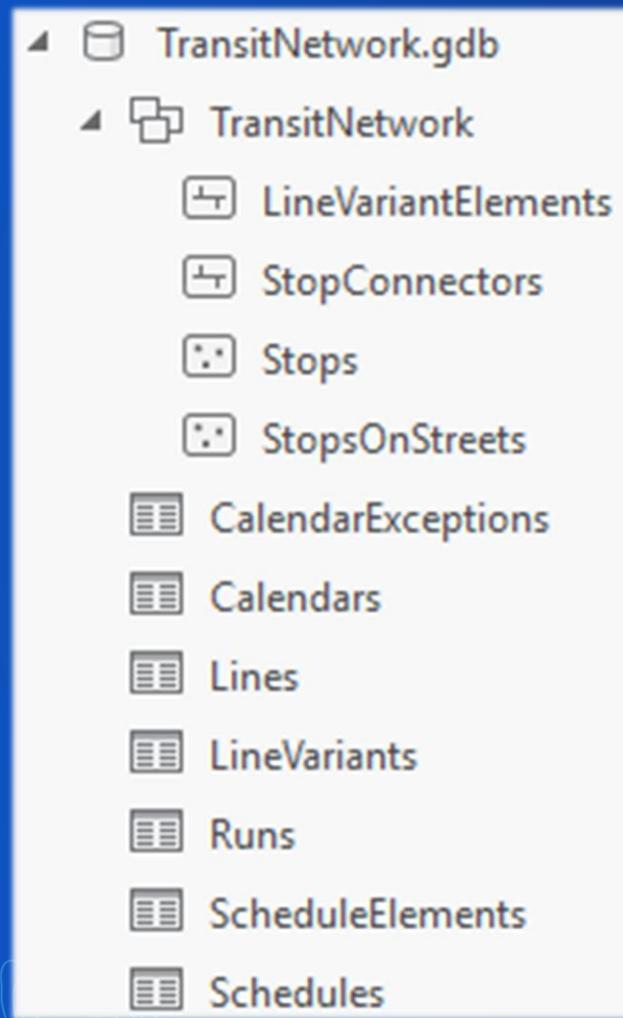


Network Analyst Public Transit Data Model

- Feature classes and tables
- Defines transit stops, lines, and schedules
- Must have specific names and schemas
- See documentation for details

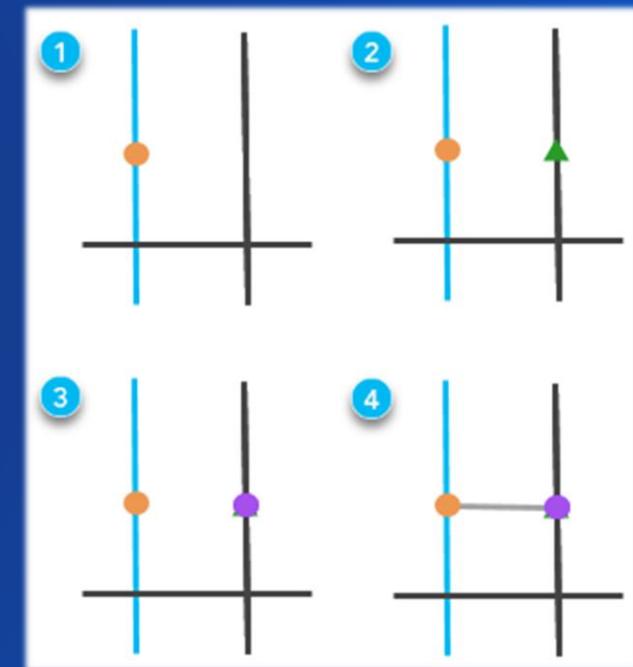


Network Analyst Public Transit Data Model

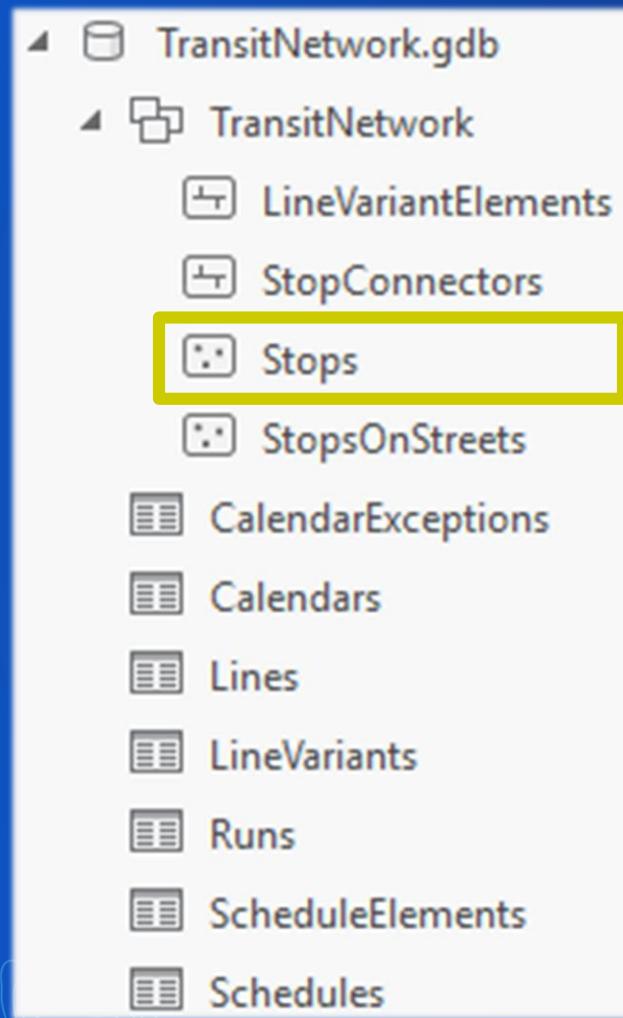


**Transit lines and stops;
connections from stops
to streets**

Transit schedules



Network Analyst Public Transit Data Model

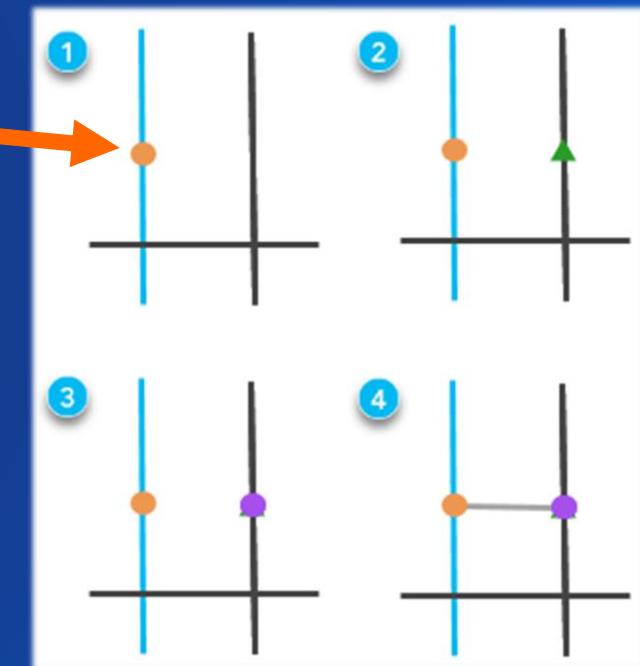


TransitNetwork.gdb

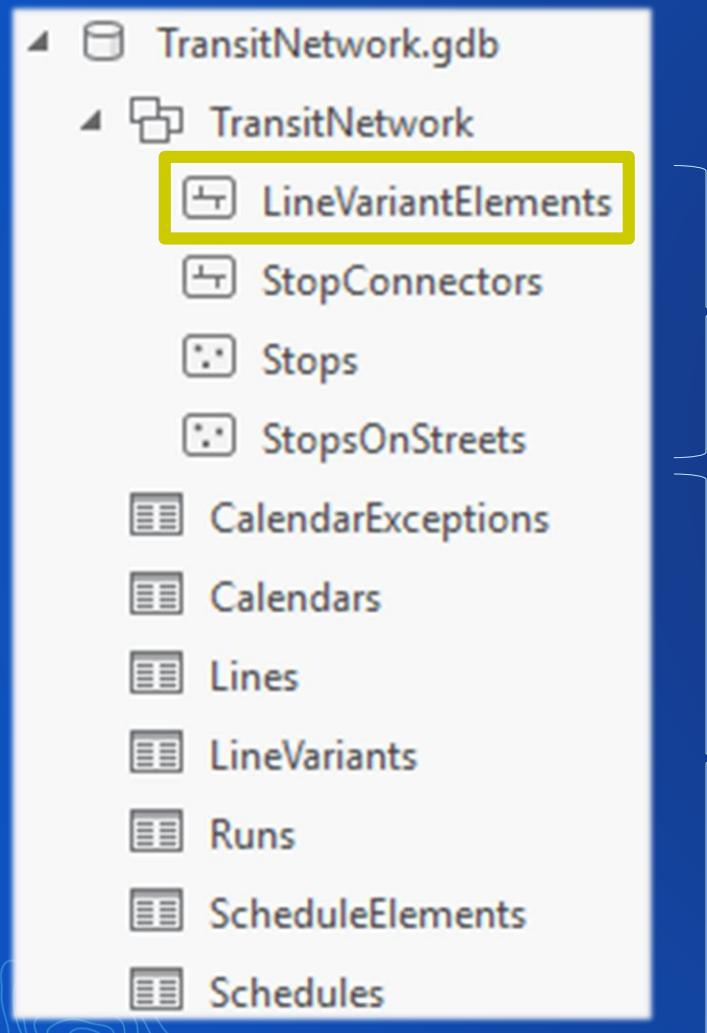
- TransitNetwork
 - LineVariantElements
 - StopConnectors
 - Stops**
 - StopsOnStreets
- CalendarExceptions
- Calendars
- Lines
- LineVariants
- Runs
- ScheduleElements
- Schedules

**Transit lines and stops;
connections from stops
to streets**

Transit schedules



Network Analyst Public Transit Data Model

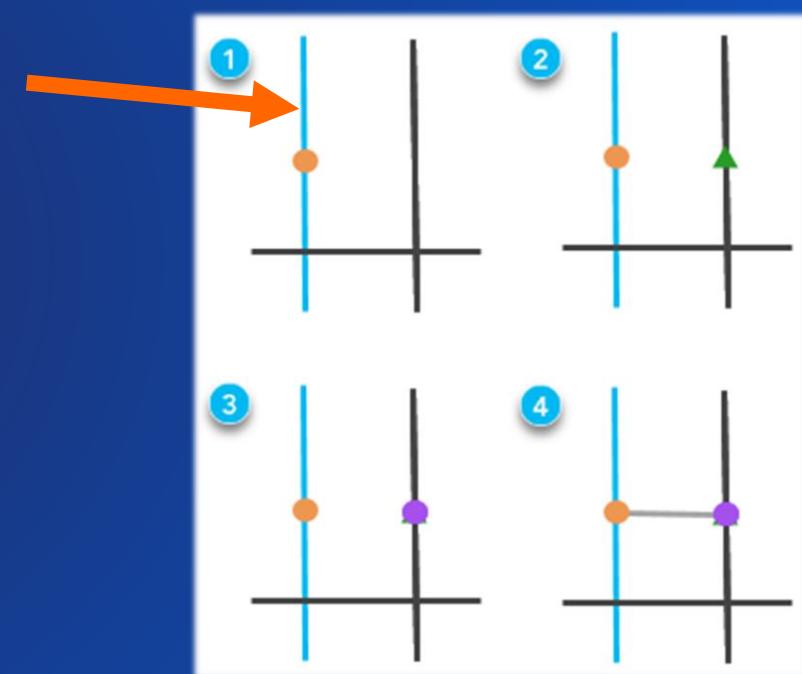


TransitNetwork.gdb

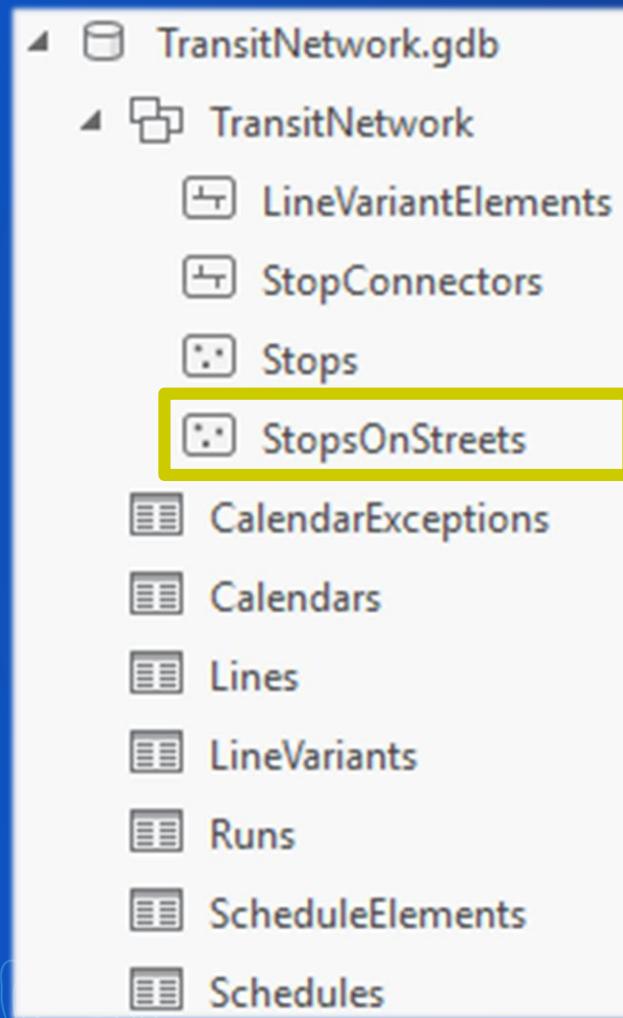
- TransitNetwork
 - LineVariantElements
 - StopConnectors
 - Stops
 - StopsOnStreets
 - CalendarExceptions
 - Calendars
 - Lines
 - LineVariants
 - Runs
 - ScheduleElements
 - Schedules

Transit lines and stops;
connections from stops
to streets

Transit schedules

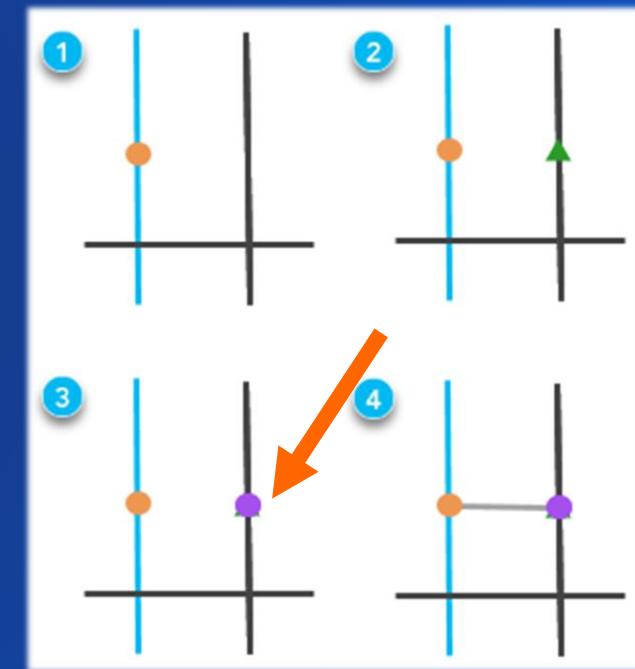


Network Analyst Public Transit Data Model

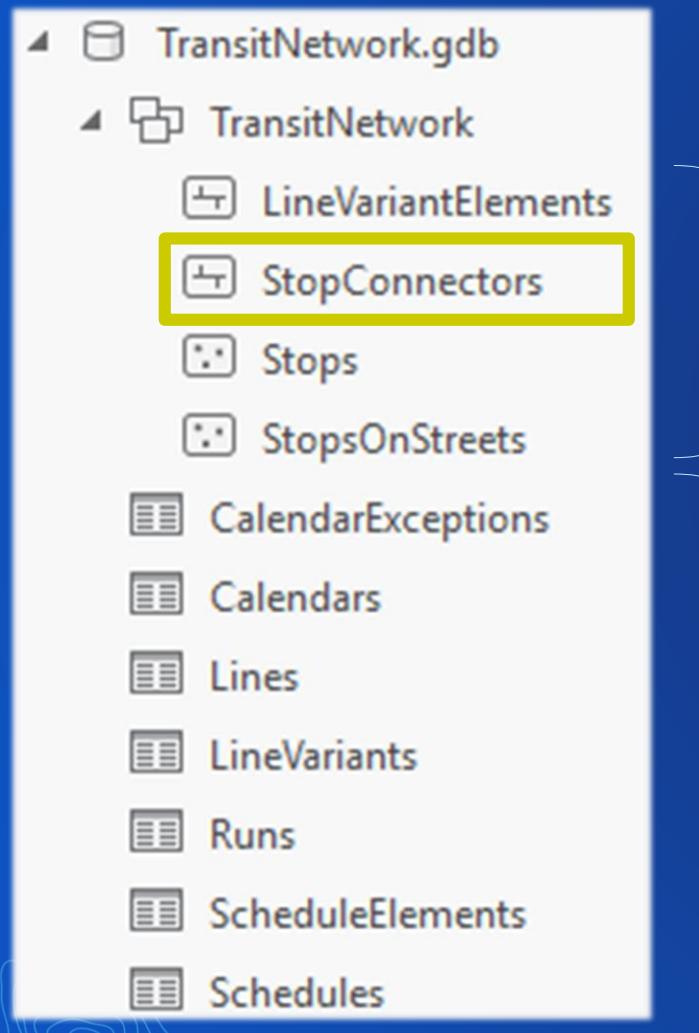


**Transit lines and stops;
connections from stops
to streets**

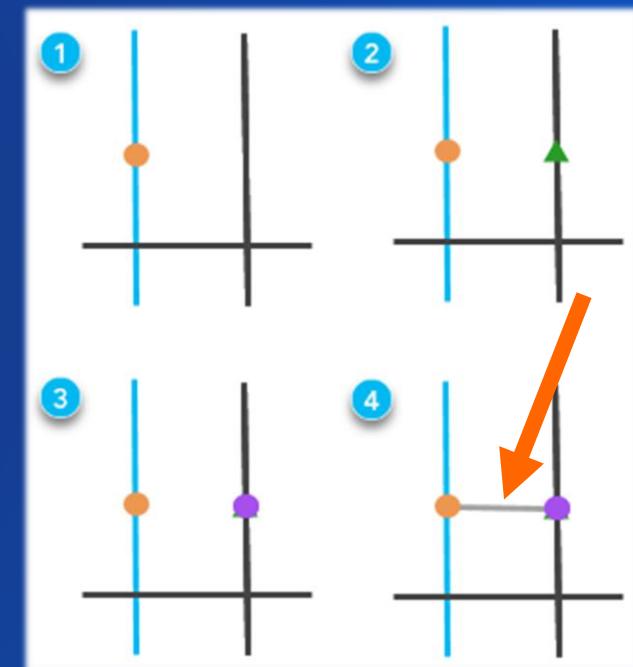
Transit schedules



Network Analyst Public Transit Data Model

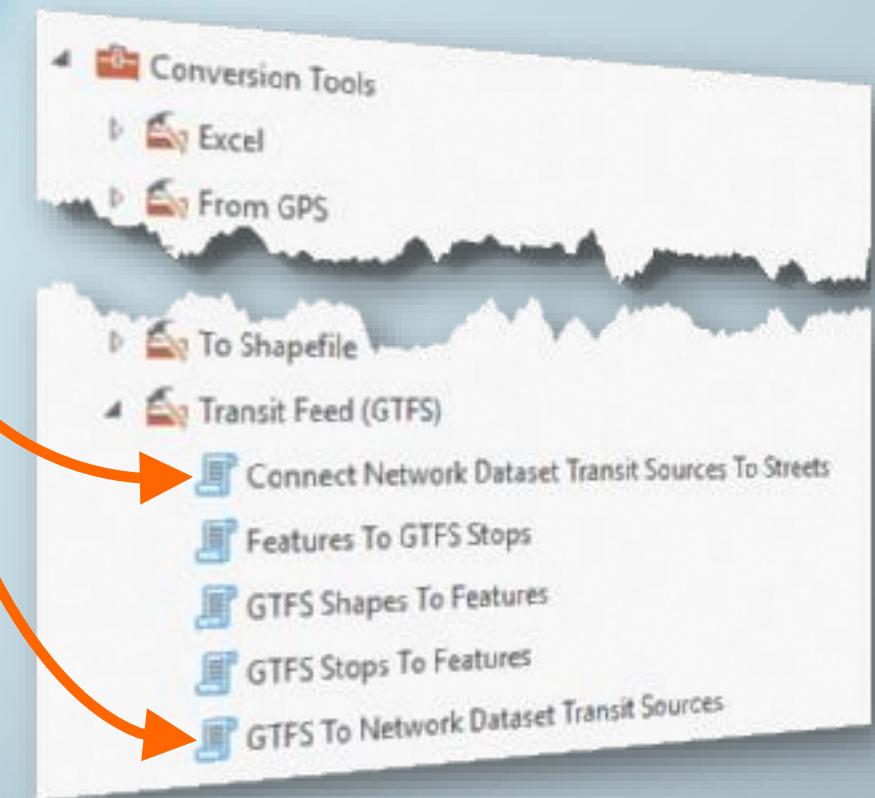


Transit schedules

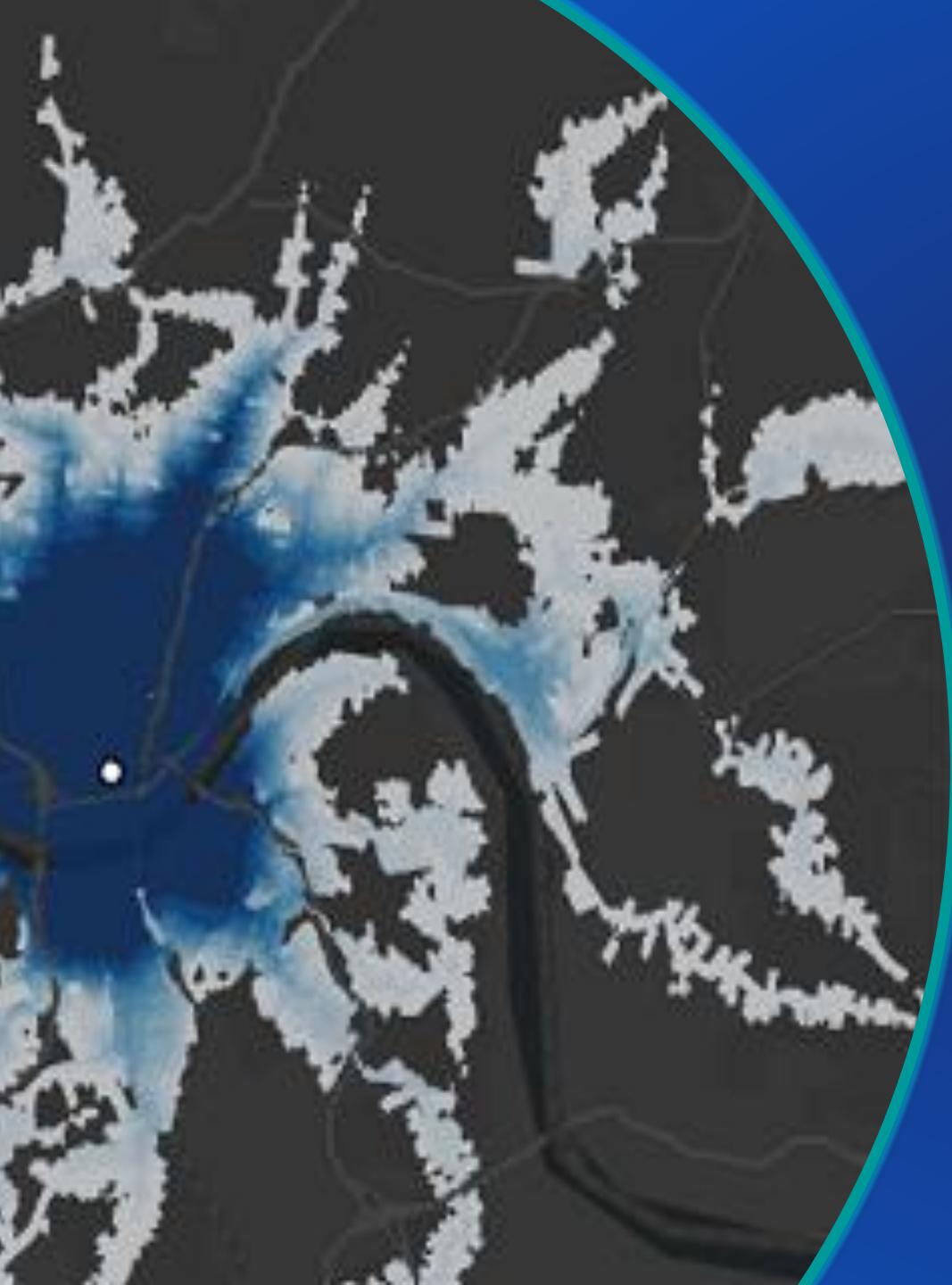


Converting from GTFS to the public transit data model

- Tools:
 - GTFS To Network Dataset Transit Sources
 - Connect Network Dataset Transit Sources To Streets
- In the Conversion Tools toolbox in “Transit Feed (GTFS)” toolset
 - Transit dataset
- Recommended to use these tools, but not required





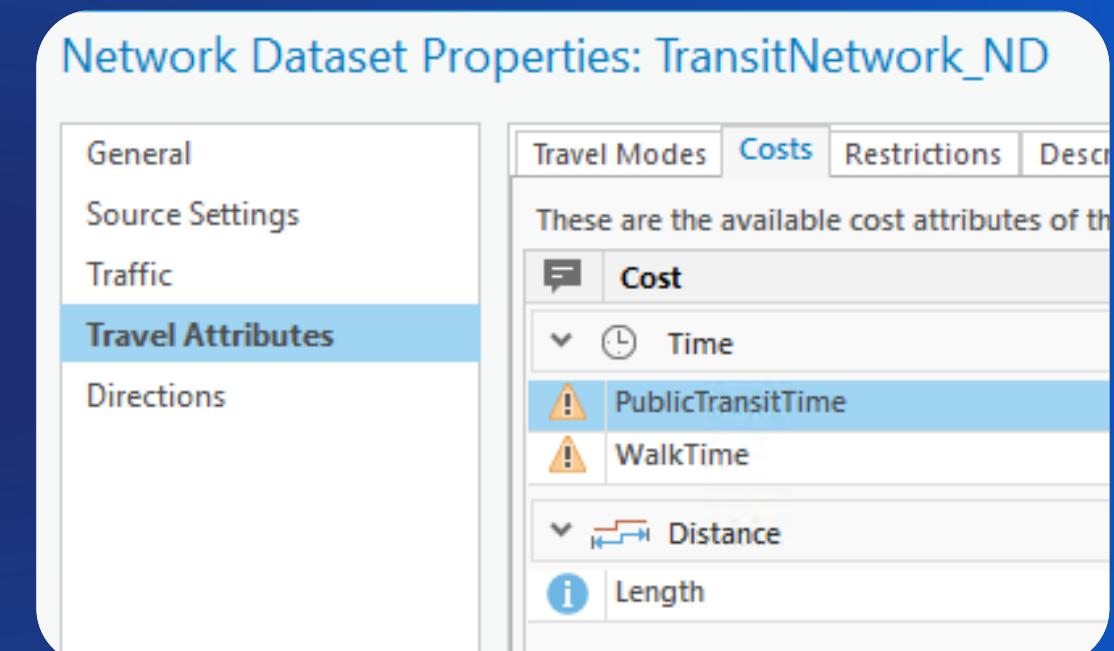


Creating the network dataset

- Use **xml template with the Create Network Dataset From Template tool**
- Obtain template from the tutorial:
<http://esriurl.com/TransitTutorial>

What is a cost attribute?

- **How much does it cost to travel along a network edge**
- **Could be time, distance, or other units**
- **Network analysis optimizes the solution based on this cost attribute**
 - Example: the fastest travel time between two points
- **Cost attributes are properties of the network dataset and part of a Travel Mode**

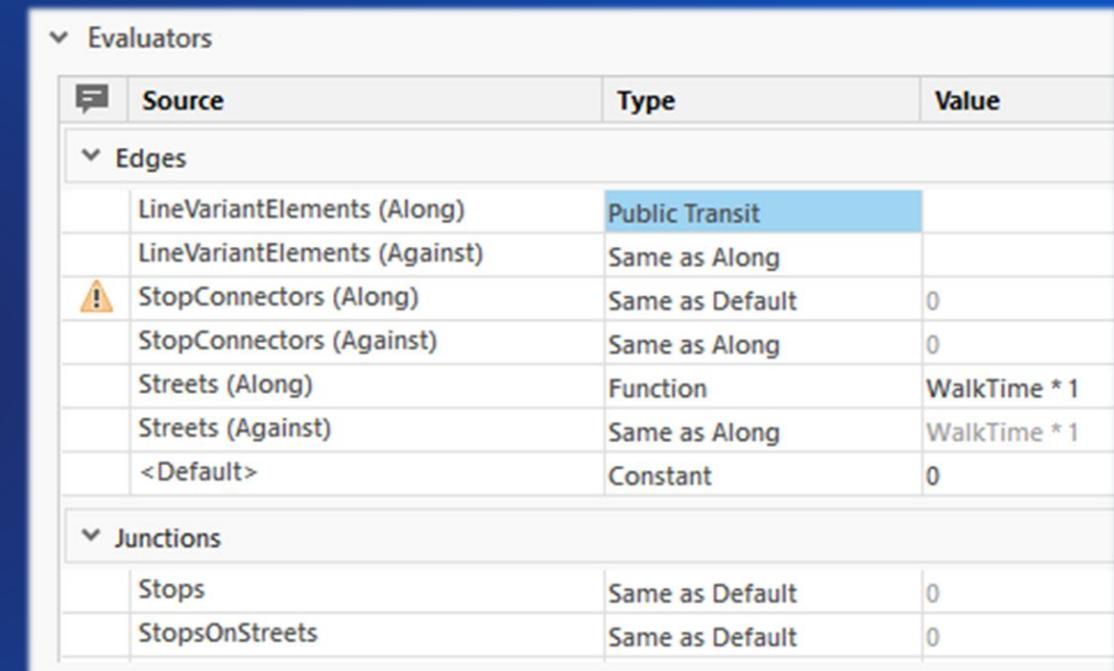


What is an evaluator?

- Tells the network how to calculate the cost for each edge
- Performs some kind of calculation
- Configured individually for network dataset sources

What is the “Public Transit” evaluator?

- Calculates cost by querying the transit schedules
- Wait time + travel time for specific time of day
- Can only be used with LineVariantElements from public transit data model



Evaluators			
Source	Type	Value	
Edges			
LineVariantElements (Along)	Public Transit		
LineVariantElements (Against)	Same as Along		
⚠ StopConnectors (Along)	Same as Default	0	
StopConnectors (Against)	Same as Along	0	
Streets (Along)	Function	WalkTime * 1	
Streets (Against)	Same as Along	WalkTime * 1	
<Default>	Constant	0	
Junctions			
Stops	Same as Default	0	
StopsOnStreets	Same as Default	0	

Limitations of the public transit evaluator

- No directions
- Cannot use with Route with optimized stop order (TSP) or with the Vehicle Routing Problem (VRP)
- Cannot separately limit walk time and overall travel time
- Cannot limit transfers

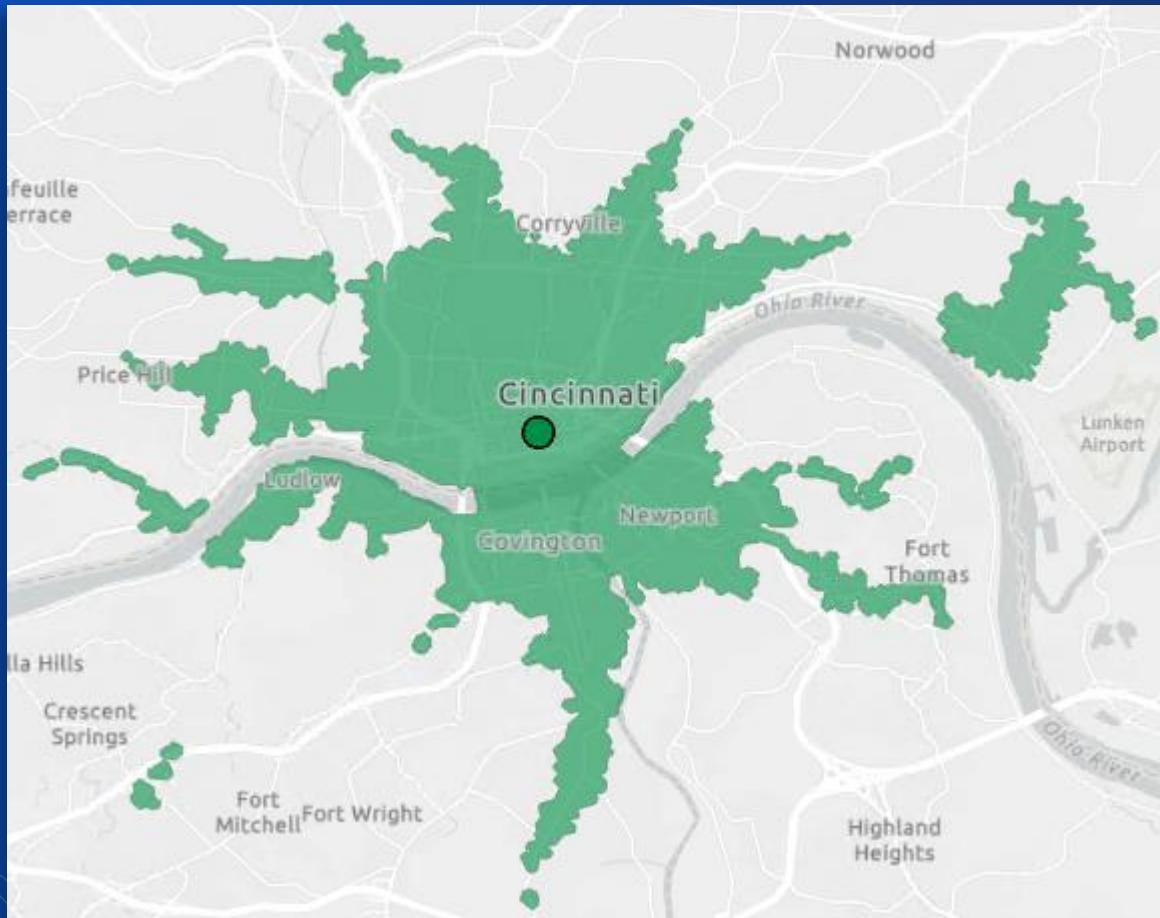


Questions

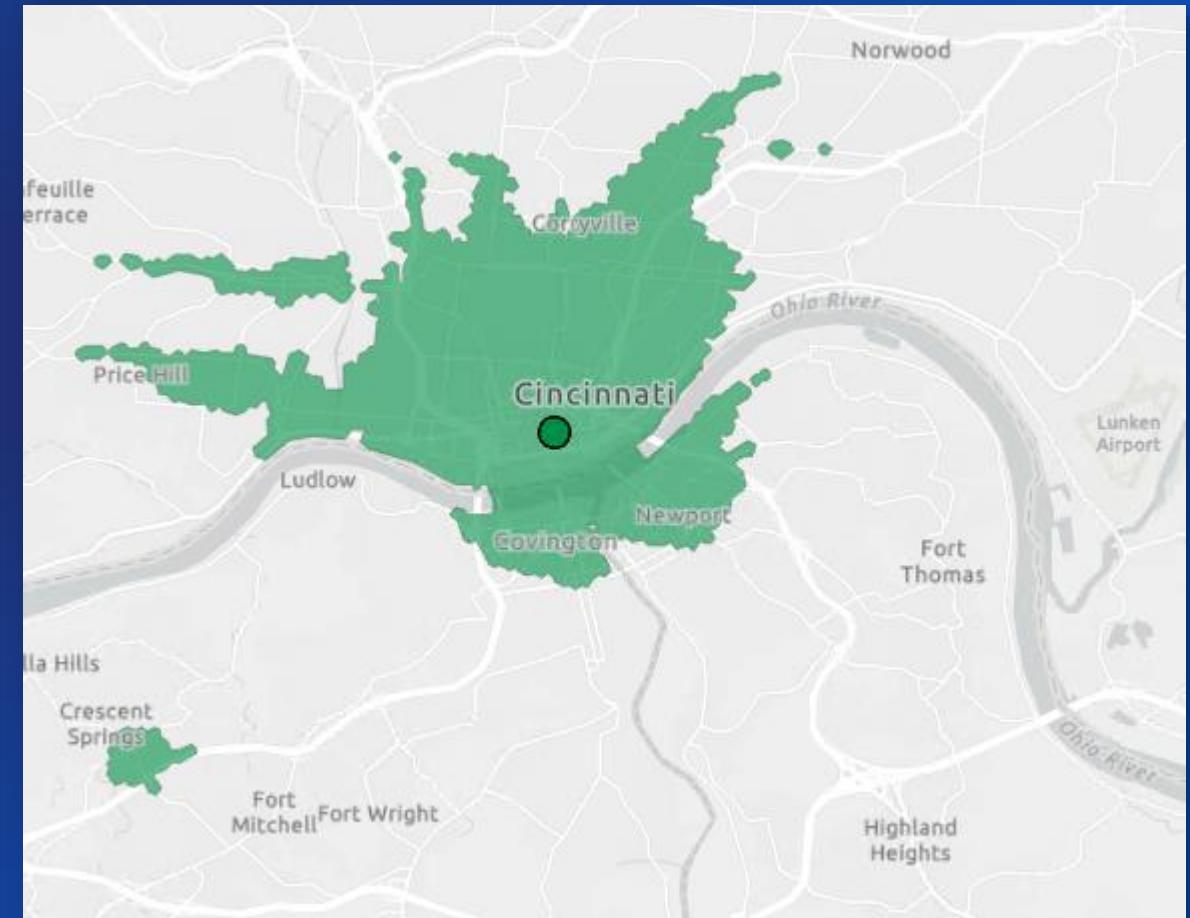
Example analysis: Analyzing access to jobs by public transit

Remember: Transit service areas differ by time of day.

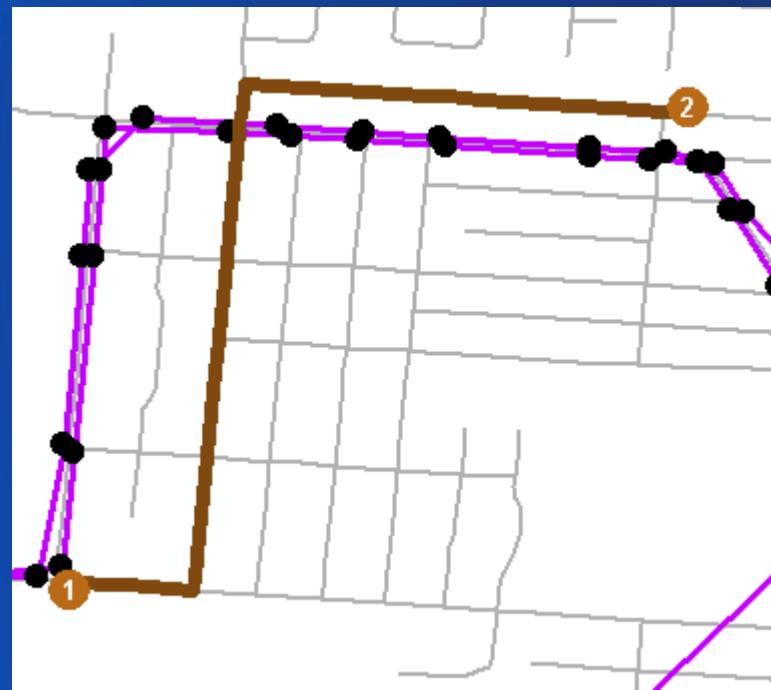
5:15 PM



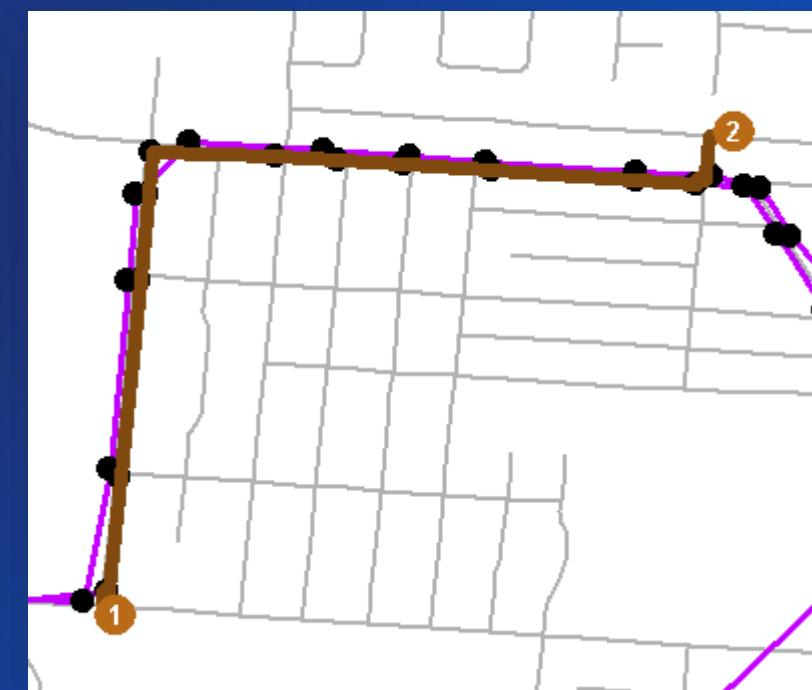
2:30 PM



Optimal route and travel time vary by time of day

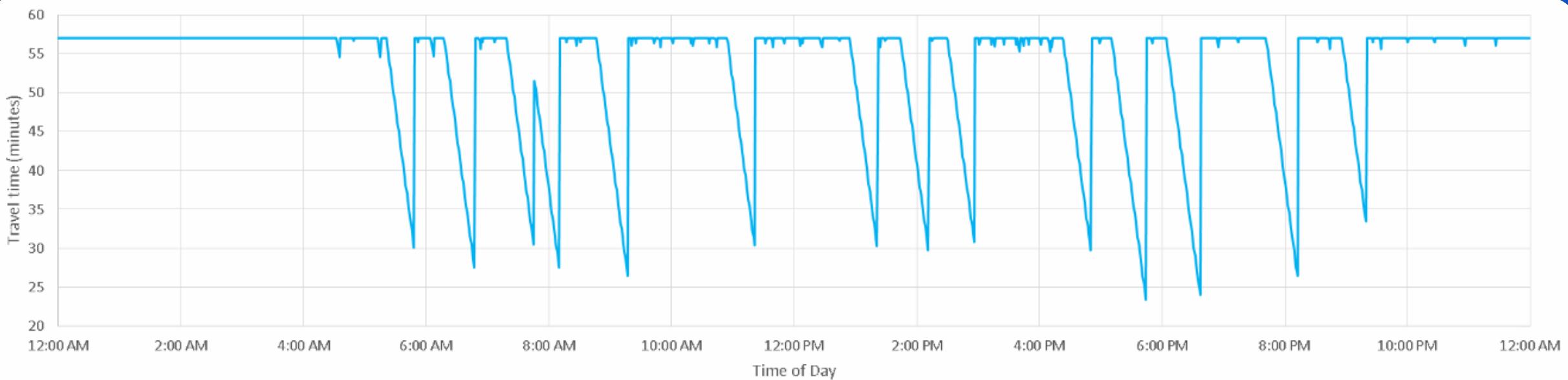


25 minutes



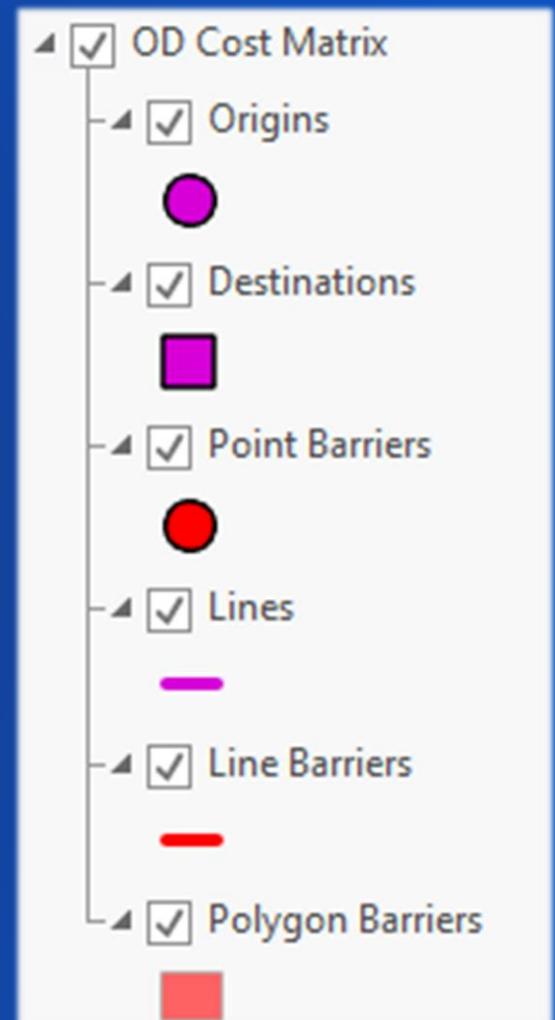
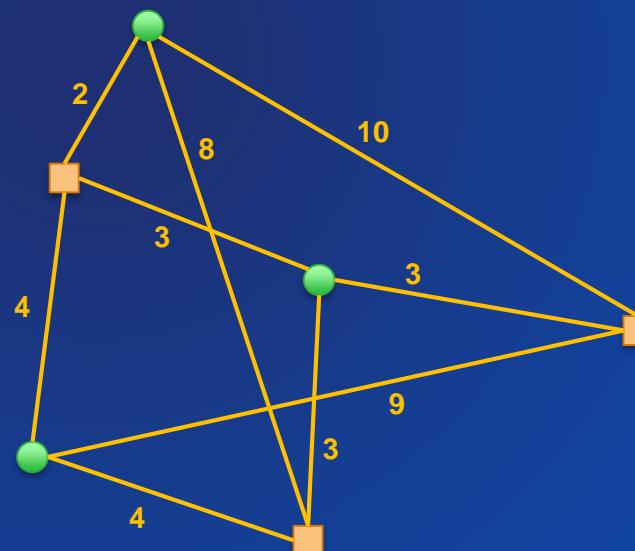
7 minutes

Travel time between two points varies

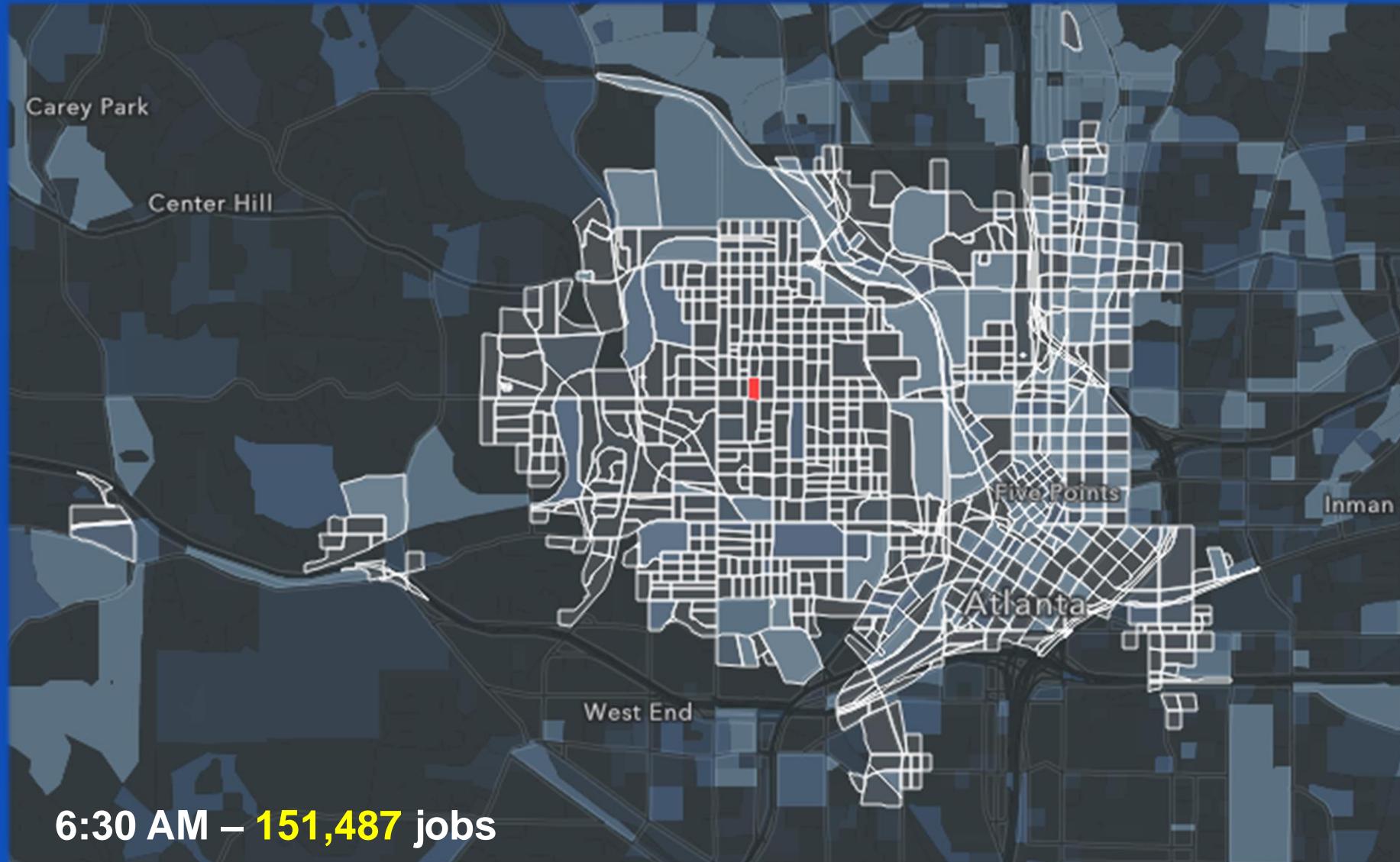


What is an Origin-Destination Cost Matrix?

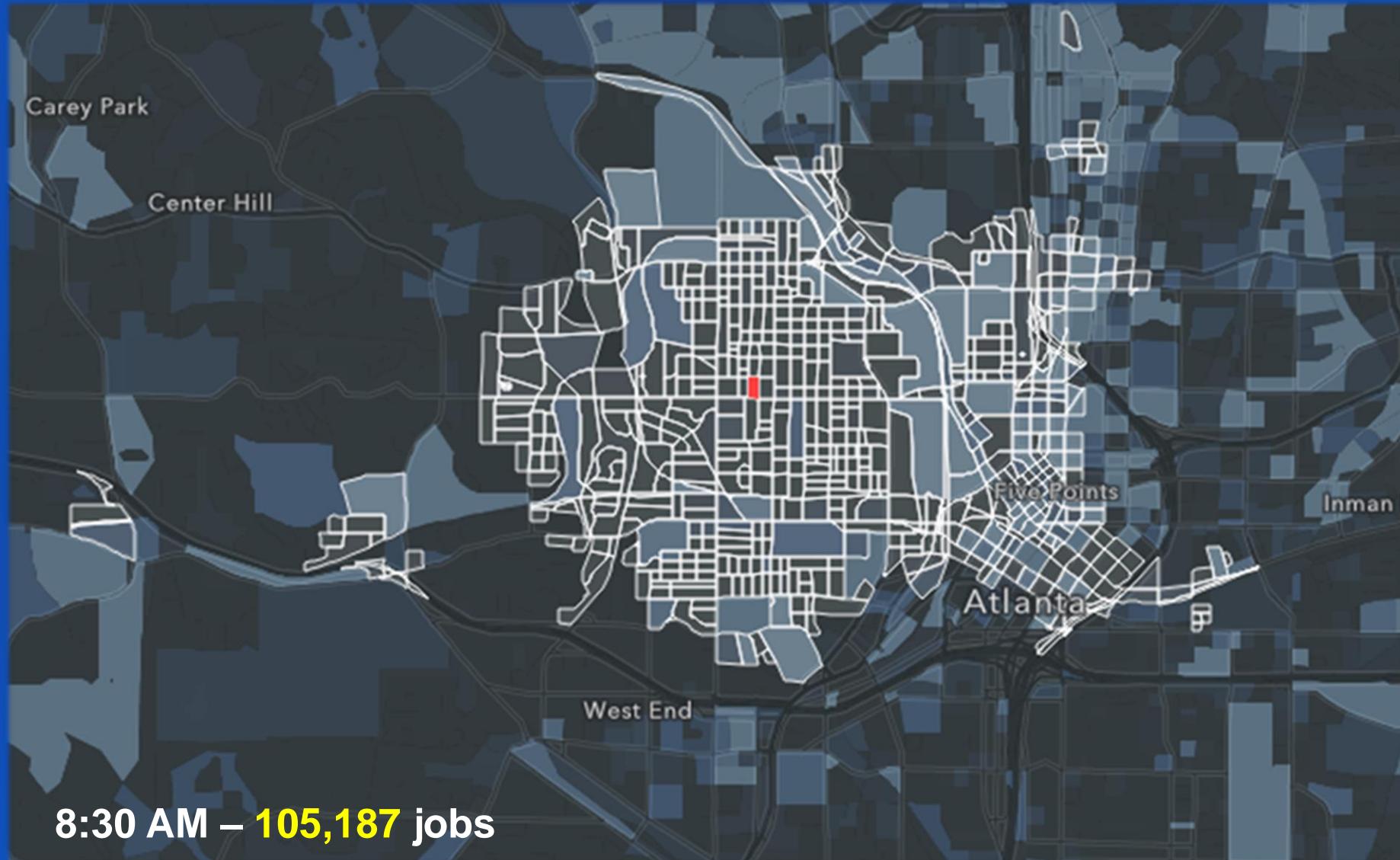
- Network Analyst tool
- Calculates travel time between each Origin and each Destination



Jobs reachable within 30 minutes from a single census block

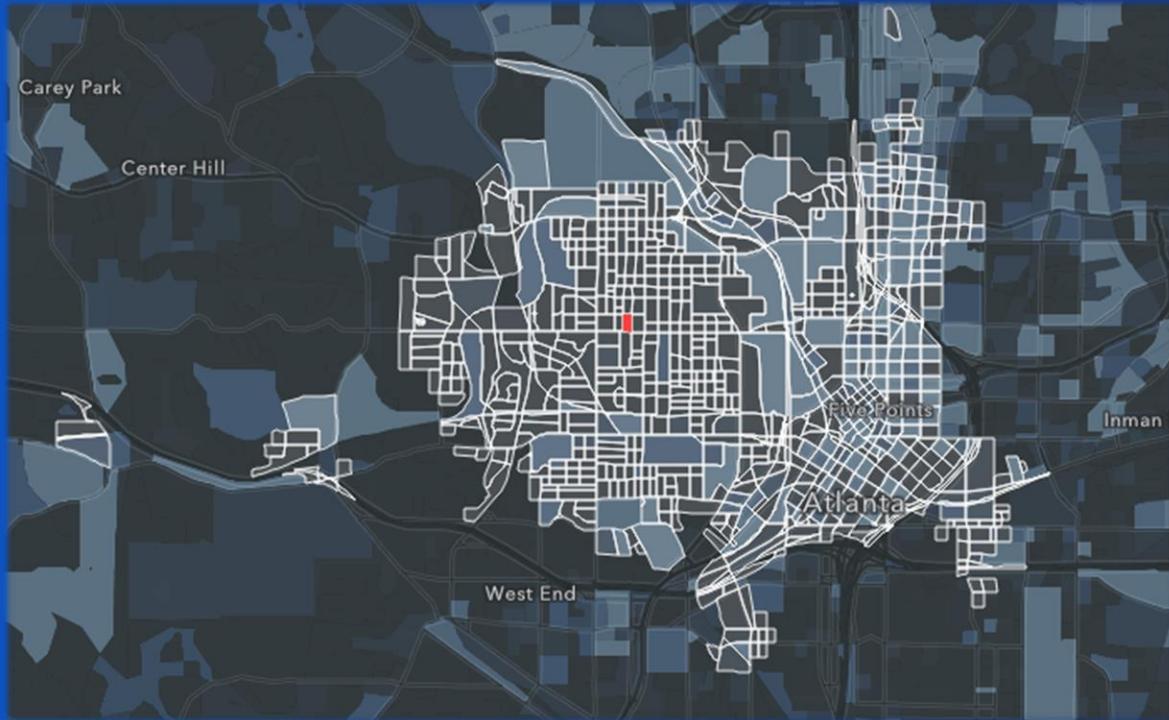


Jobs reachable within 30 minutes from a single census block

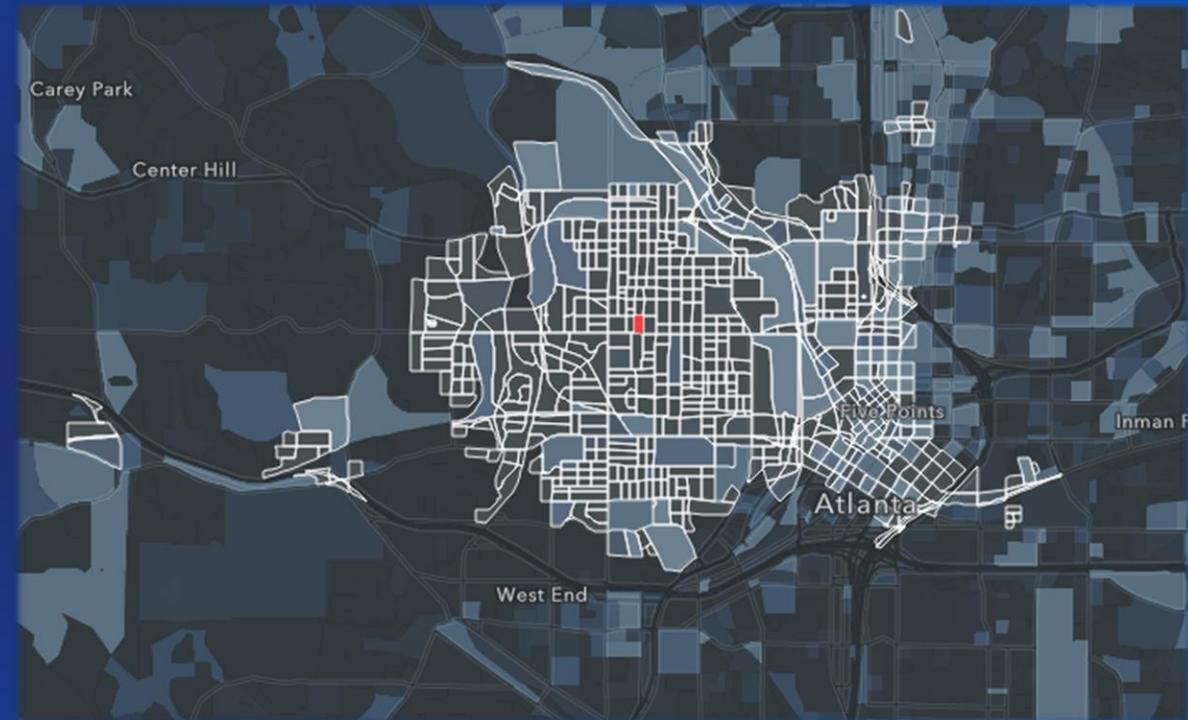


Jobs reachable within 30 minutes from a single census block

6:30 AM – 151,487 jobs



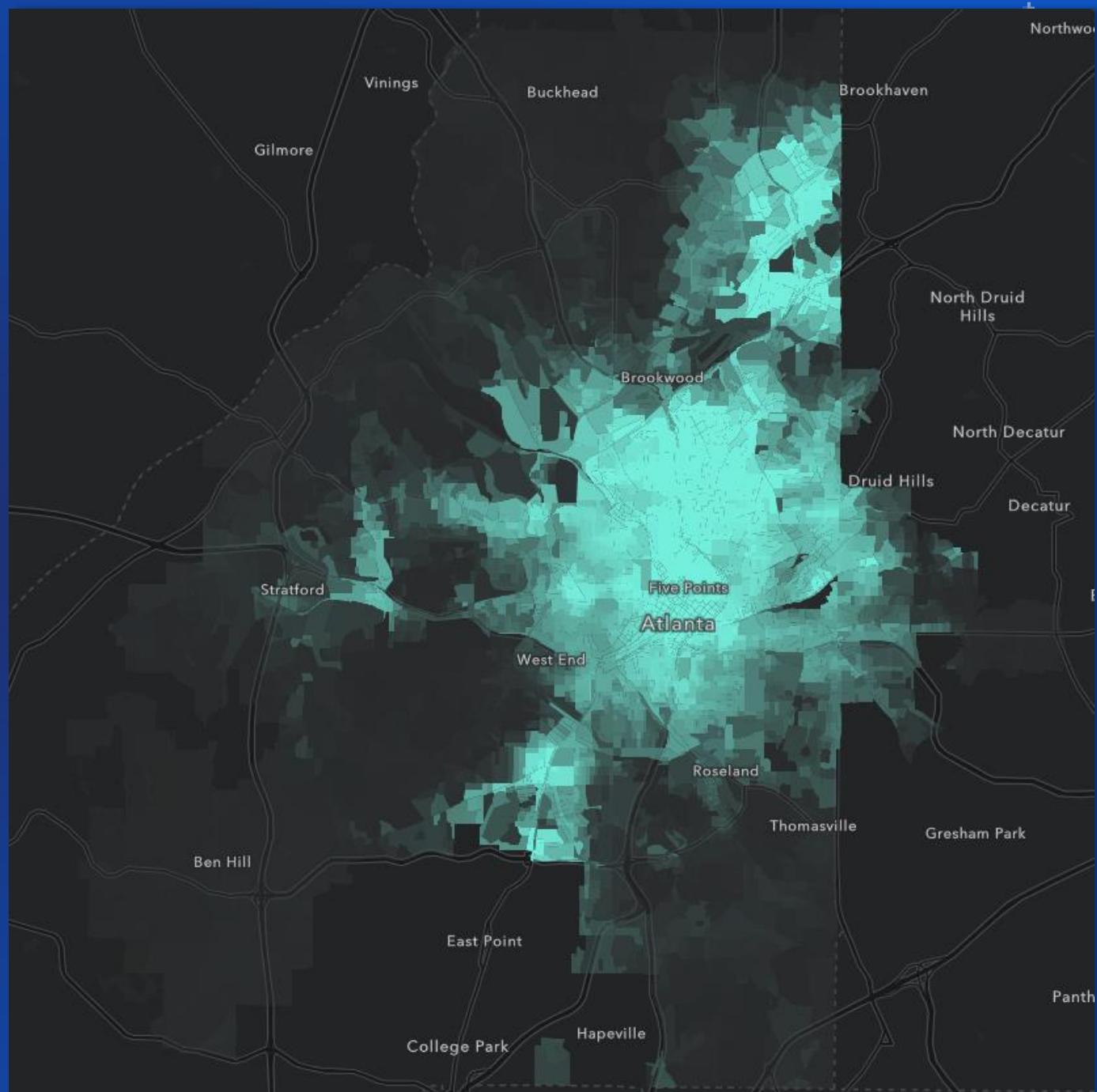
8:30 AM – 105,187 jobs



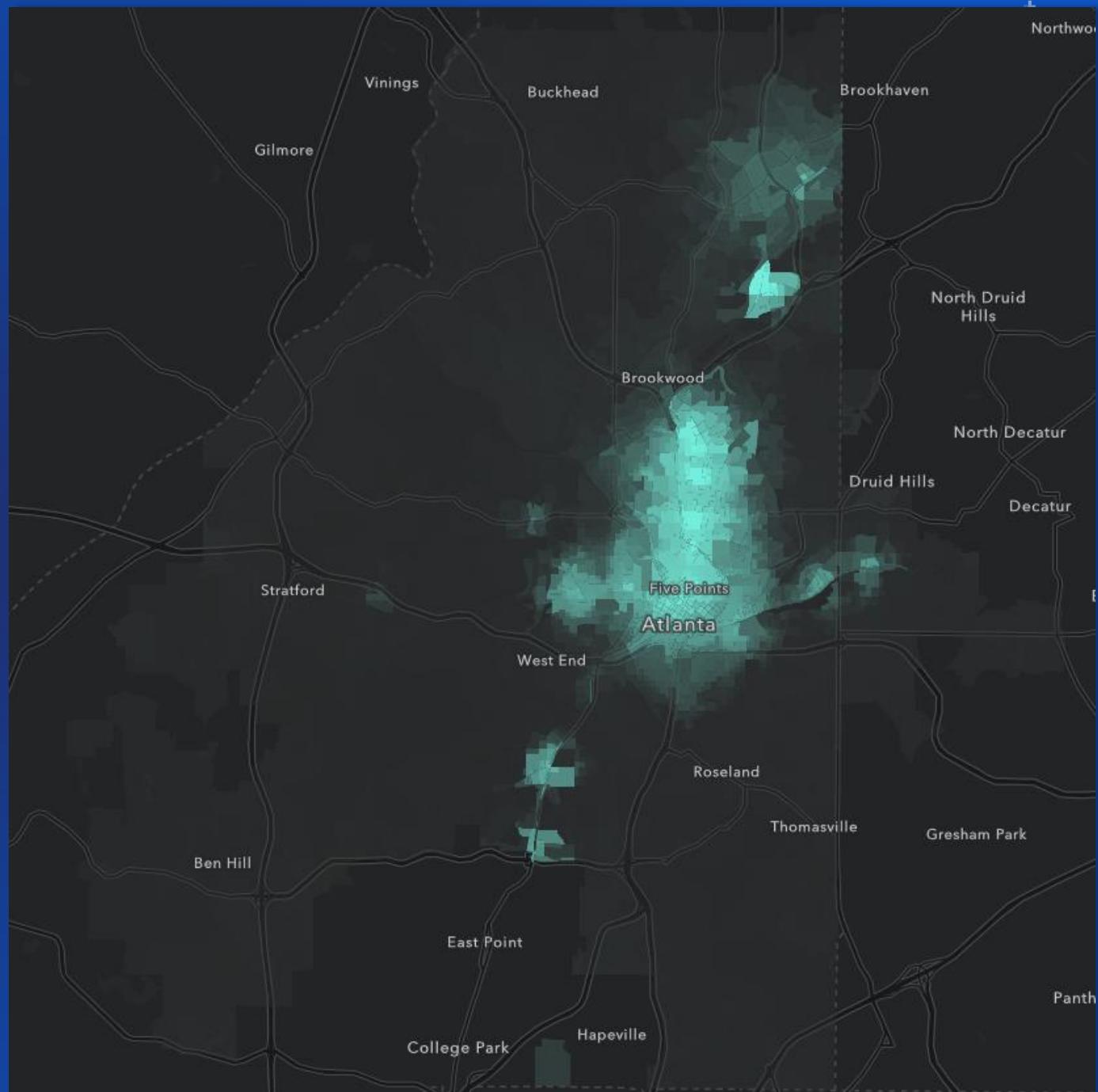
**Jobs accessible at least once between 6:30AM and 9:30AM:
204,381**

**Jobs accessible at least 90% of start times:
67,680**

**Jobs reachable at least once
within 30 minutes
from every census block**



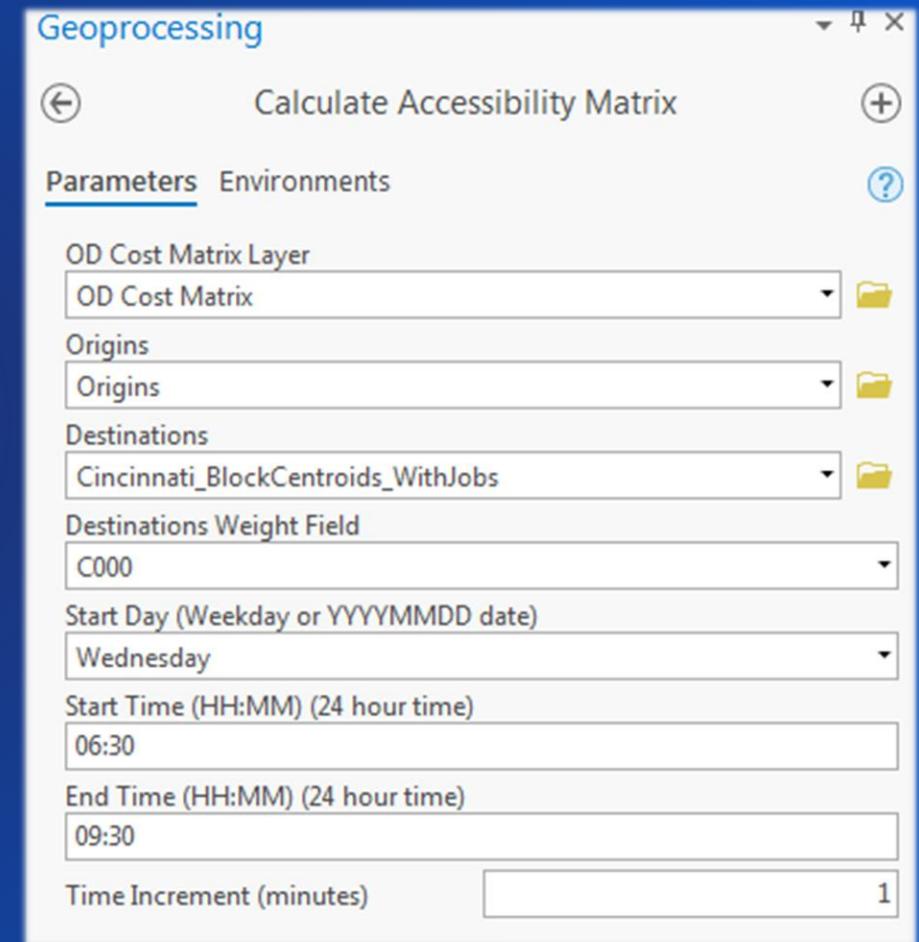
Jobs reachable frequently within 30 minutes from every census block



Calculate Accessibility Matrix tool

- **Solve OD Cost Matrix**
- **Iterate through times of day**
- **Count number of destinations reachable**
 - At least once
 - More than x% of times

Download at
<http://esri.github.io/public-transit-tools/>
(part of the Transit Network Analysis Tools
toolset)



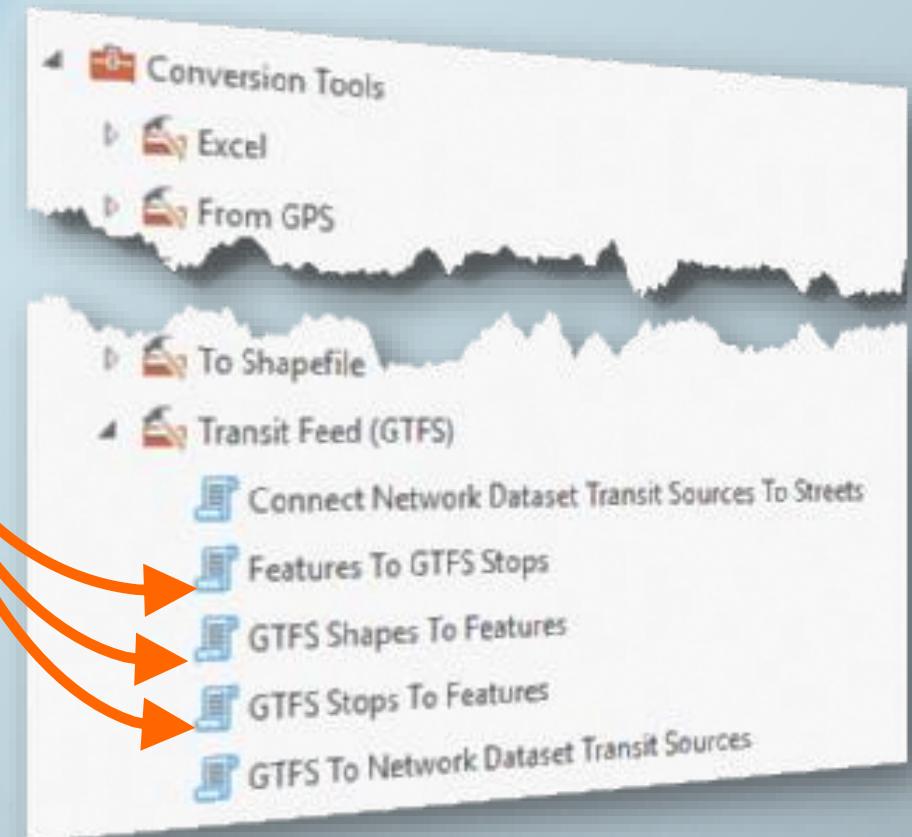
Questions?

Other Cool Things

Other GTFS tools in ArcGIS Pro

For displaying and editing GTFS data

- Located in the **Conversion Tools** toolbox in the **Transit Feed (GTFS) toolset**
- **Displaying data**
 - **GTFS Shapes To Features**
 - **GTFS Stops To Features**
- **Editing GTFS stops**
 - **Features to GTFS Stops**



Other downloadable tools

And sample analyses...

- **Downloadable tools for transit analysis and editing**
- **Sample analyses**
- **Links to other resources**



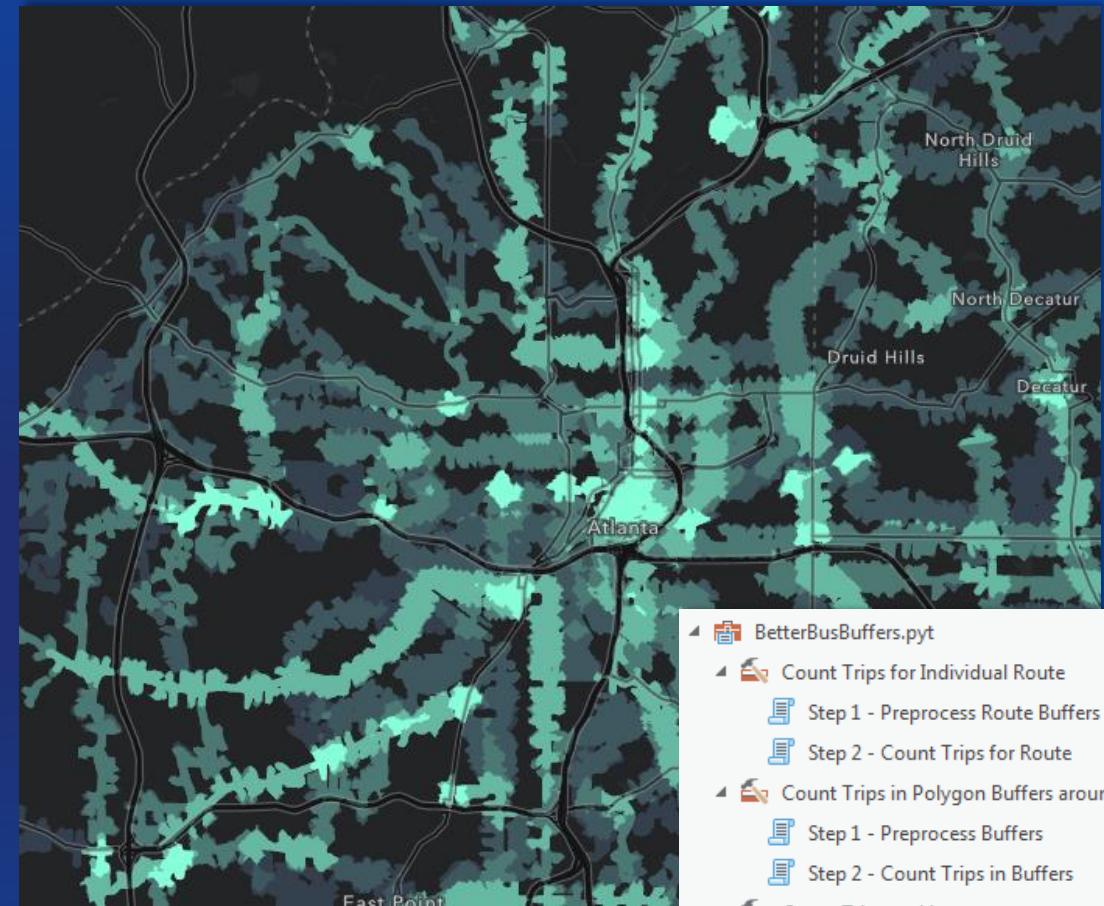
The General Transit Feed Specification (GTFS) is a standardized data format for storing public transit routes, stops, and schedules. GTFS data can be used for transit trip planning and public transit system analysis. Thousands of public transit agencies worldwide have made up-to-date GTFS data for their systems publically available for download.

Download tools from

<https://esri.github.io/public-transit-tools/index.html>

BetterBusBuffers

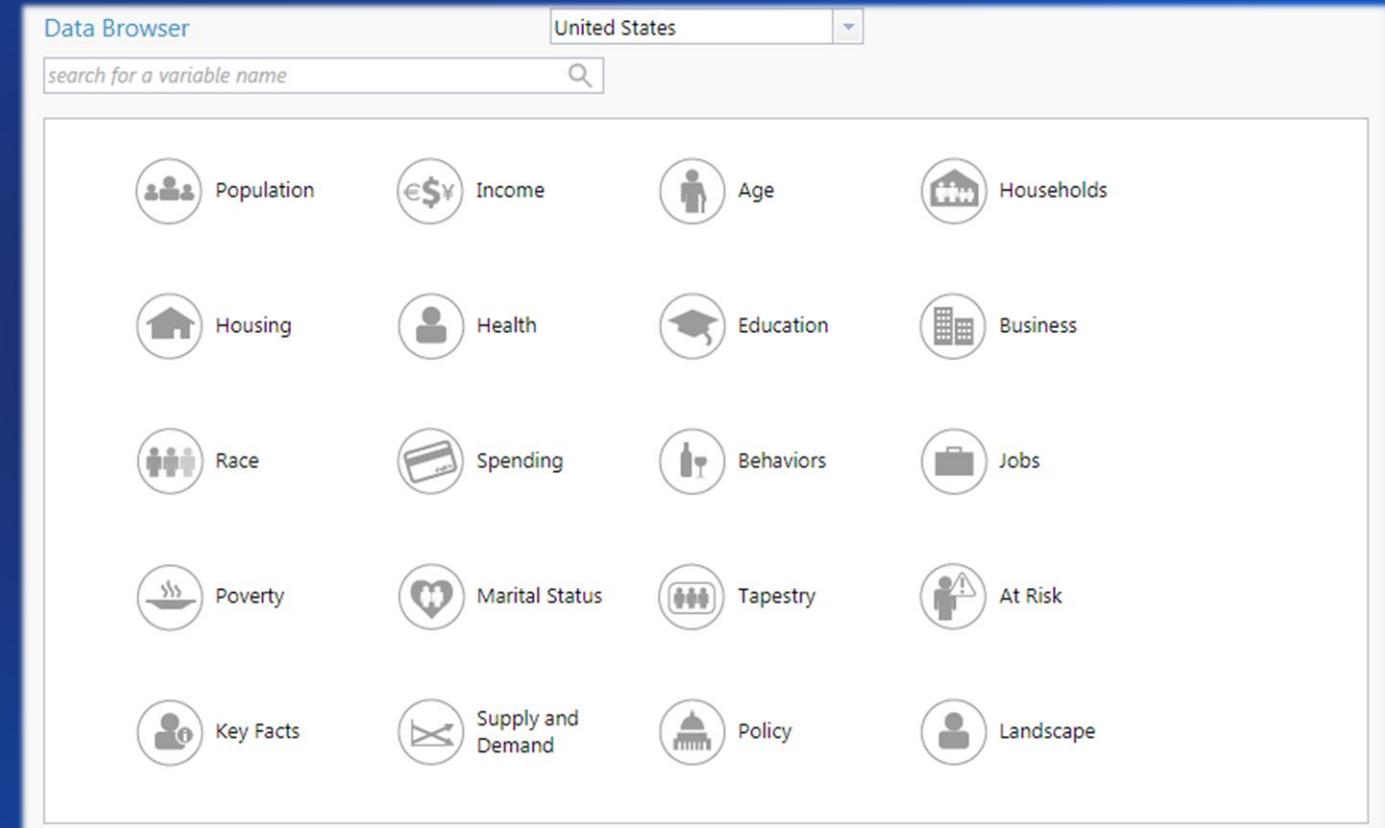
- Count how many trips per hour visit my stops during a time window
- Weight my system's service area map by frequency
- Calculate the frequency of service available at points of interest



- ✚ BetterBusBuffers.pyt
 - ✚ Count Trips for Individual Route
 - Step 1 - Preprocess Route Buffers
 - Step 2 - Count Trips for Route
 - ✚ Count Trips in Polygon Buffers around Stops
 - Step 1 - Preprocess Buffers
 - Step 2 - Count Trips in Buffers
 - ✚ Count Trips on Lines
 - Step 1 - Preprocess Lines
 - Step 2 - Count Trips on Lines
 - Count High Frequency Routes at Stops
 - Count Trips at Points
 - Count Trips at Points Online
 - Count Trips at Stops
 - Preprocess GTFS

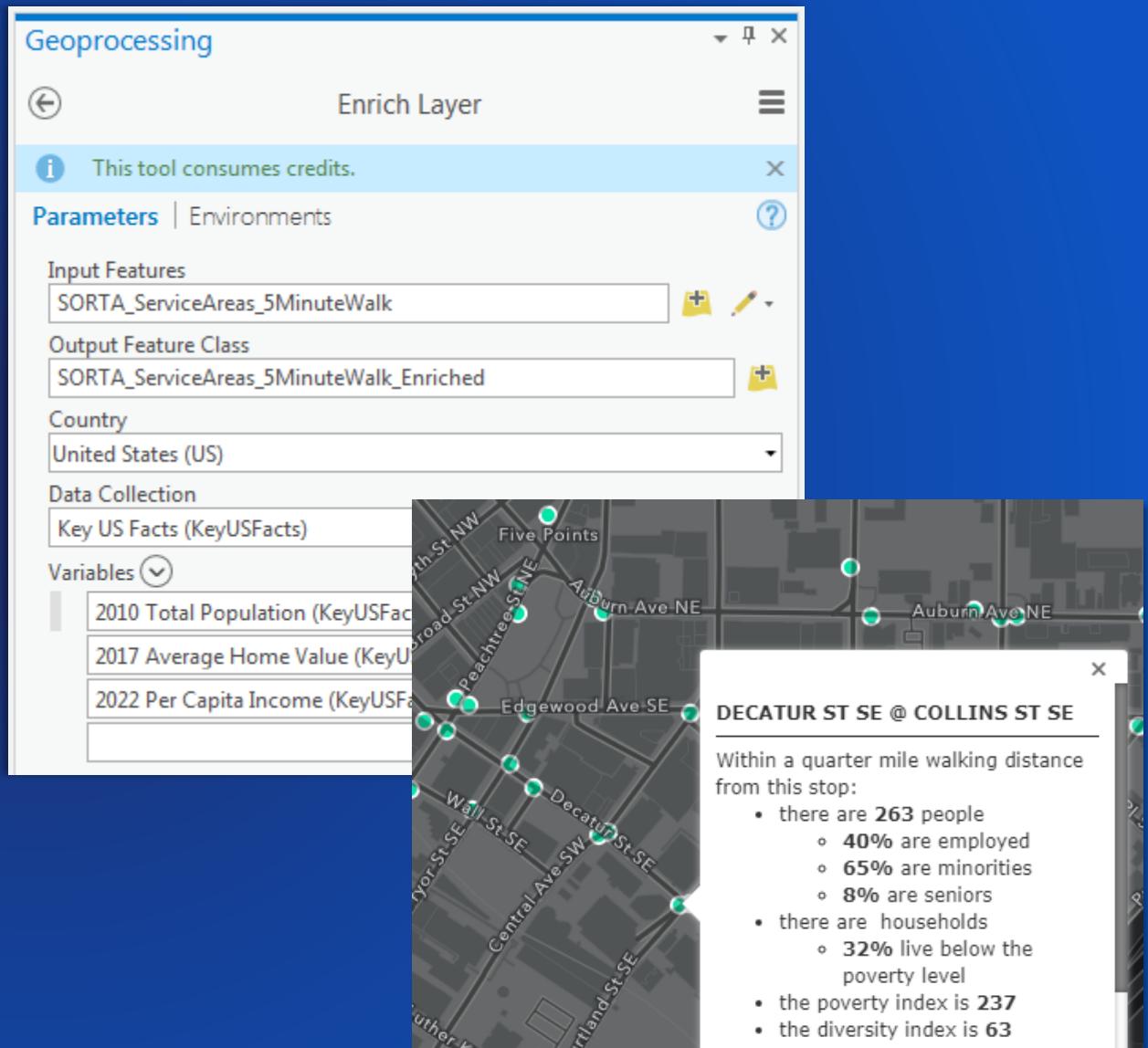
Esri Demographics

- Demographic data
- Business data
- Current
- Worldwide
- Derived from Census, ACS, and many other sources
- Curated by a team of experts



Data enrichment

- Add demographic data to arbitrary polygons (or points!)
- Enrich Layer tool
 - ArcGIS Pro
 - ArcGIS Online
- Uses service credits



Wrap-up

Resources

Tutorial

<http://esriurl.com/TransitTutorial>

Downloadable tools

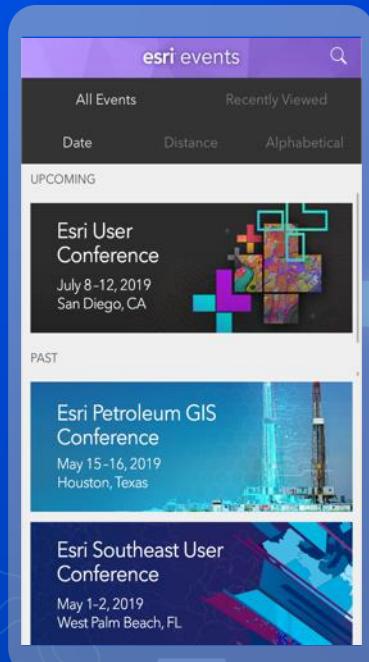
<https://esri.github.io/public-transit-tools/index.html>

GeoNet group

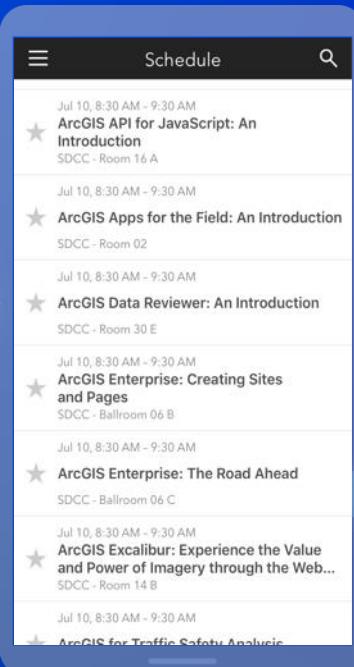
<https://community.esri.com/community/arcgis-for-public-transit>

Please Share Your Feedback in the App

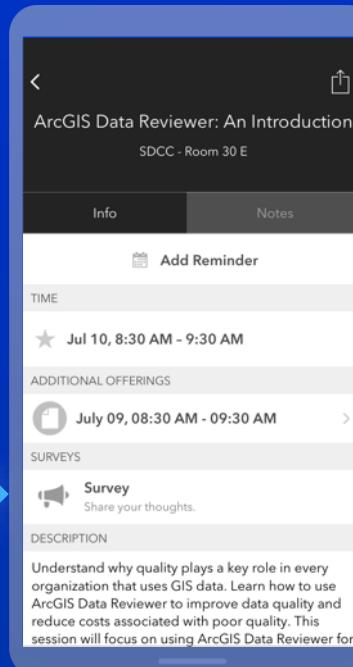
Download the Esri Events app and find your event



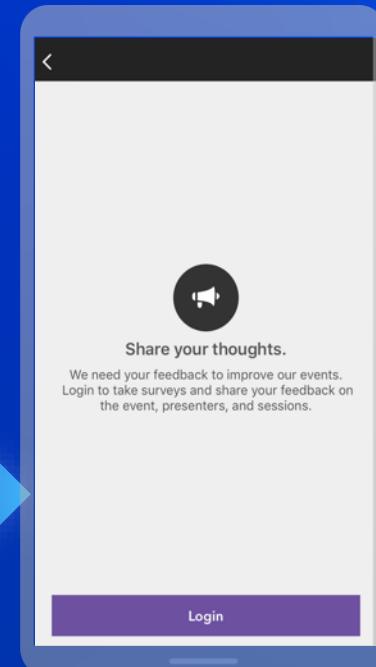
Select the session you attended



Scroll down to "Survey"



Log in to access the survey



Complete the survey and select "Submit"

